REMARKS/ARGUMENTS

Claims 1-14 and 17-191 are pending in the application. Applicant appreciates the examiner's allowance of claims 1, 10-13, 20-40 and 104-125. Claims 2, 8, 14, 19, 126, 148 and 170 are amended in the present amendment.

Claims 14, 17, 18, 63-82 and 148-169 are rejected under 35 U.S.C. § 112, second paragraph, as being indefinite for failing to particularly point out and distinctly claim the subject matter of the invention. Independent claims 14 and 148 are amended to correct any indefiniteness in the claims. Claims 17, 18 and 63-82 are dependent claims dependent upon independent claim 14, and thus should be allowable for the above reasons as well as for the additional elements they contain. Claims 149-169 are dependent claims dependent upon independent claim 148, and thus should be allowable for the above reasons as well as for the additional elements they contain.

Claims 19, 83-103 and 170-191 are objected to because the examiner believes the word "fusing" should be changed to "aligning" in claims 19 and 170. Claims 19 and 170 are amended by changing the word "fusing" to "aligning." Claims 83-103 are dependent claims dependent upon independent claim 19, and thus should be allowable for the above reasons as well as for the additional elements they contain. Claims 171-191 are dependent claims dependent upon independent claim 170, and thus should be allowable for the above reasons as well as for the additional elements they contain.

Claims 2, 3, 5, 9, 14, 18, 19, 41, 42, 60-63, 81-84, 102, 103, 126-128, 146-150, 168-172, 190 and 191 are rejected under 35 U.S.C. § 102(b) as being anticipated by U.S. Patent No. 5,552,605 to Arata. Applicant respectfully traverses this rejection.

The Arata reference discloses a method to compensate for patient motion in diagnostic imaging. Some patient motion is common given the long scan times for some single photon emission computed tomography (SPECT) imaging procedures. The Arata reference provides a method and apparatus for correcting image distortions caused by motion occurring during a SPECT imaging procedure.

During the procedure disclosed in the Arata reference, a radiation detector is rotated around a patient at incremental projection angles. The radiation detector produces electrical data indicative of received radiation from an examination region. At each projection angle, the electrical data forms a two-dimensional projection view of a region of interest within the patient. A reconstruction processor reconstructs the multiple projection views into a three dimensional reconstructed image representation of the region of interest. A reprojection circuit reprojects the reconstructed image representation at each of the original projection angles to produce a set of reprojection views. A view comparator compares each projection view within a region of interest with a corresponding reprojection view produced at the same projection angle. An offset between these two views is determined and the projection view is translated by this offset to produce a corrected projection view. The corrected projection views are reconstructed into a corrected three-dimensional reconstructed image representation. In other words, the Arata reference provides a method and apparatus for motion correction based on reprojection data.

There are many common prior-art processes like image reconstruction, sinogram reprojection, and image registration that are well known and used in various imaging processes. Image reconstruction is defined as converting a raw sinogram data set into an image. Sinogram reprojection is defined as converting an image into a sinogram data set. Image reconstruction and sinogram reprojection are simple inverses of each other. The process known as iterative reconstruction and reprojection (IRR) has existed for many years (e.g. G. T. Herman and A. Lent, "Iterative reconstruction algorithms," Comput. Biol. Med., vol. 6, pp. 273-294, 1976). One option for IRR is as a means to reconstruct images given unflawed data.

The data set of projection views acquired in the process disclosed in the Arata reference is complete, but potentially inconsistent due to patient motion. The Arata method operates to reconstruct an initial image from raw sinogram data, then reproject new sinogram data from this first reconstructed image, and finally to shift the raw sinogram data to be consistent with the reprojected sinogram data. This shifted raw sinogram data is reconstructed into an updated image. This all occurs during a single iterative process.

The present invention provides a method of reconstructing incomplete data sets, which otherwise cause distinctive artifacts. The Arata reference only discloses the application of deblurring patient motion. These two types of degradations have different sources, affect the collected data volumes in different ways, have different effects on the images, and consequently, require different solutions. The Arata reference does not discuss other applications besides deblurring patient motion, and certainly makes no reference to compensating for limited data availability. On the contrary, the Arata reference implicitly assumes complete data sets in that it

never even mentions the possibility of missing necessary scan data, and the method would not mitigate the degradation caused by limited data availability. In the Arata reference, both the initial and final images would be degraded.

The present invention provides the incorporation of *a priori* data, or imperfect *a priori* data. This is an important distinction from Arata. The Arata reference discloses modifying the original sinogram based upon comparisons with a reconstructed and reprojected version of itself (self-consistency), whereas incorporating additional data from a separate independent image or sinogram data set is fundamental to the present invention and very different from anything disclosed in the Arata reference. The present invention "augments" the image data, which is a way to create a new sinogram with the missing regions filled-in by intelligently estimating them from a separate data set; whereas the Arata reference "shifts" the image data, which is a way to create an adjusted sinogram by using the same complete data, but rearranging it to "undo" patient motion. Finally, the registration process of the present invention is different from the registration process of the Arata reference. In the present invention, registration is typically done in image space. This is possible because there are two independent images (re: the new image we are working on, and the *a priori* image.) The registration of the present invention may also be done in sinogram space. The Arata reference cannot register in image space because there is only one image. It is not until the completion of the iteration (reprojecting, registering in sinogram space, and reconstructing again) that a second image is created. And the second image is not a second independent image, but an improved version of the first image.

The Arata reference does not disclose the possibility of having limited data; or for compensating for limited data. The Arata reference does not disclose using *a priori* data sets to improve the image quality. Arata makes no provision for large patients, or other situations in which the data would be incomplete, even though these situations would impact Arata's image quality, and Arata's correction technique would not compensate for such degradations.

Arata's process only uses a single image at a time (i.e. for each iteration) in an iterative process. There is no separate and independent second image, and there is no disclosure of working with two images at a time. Instead, each iteration of the process begins with a single sinogram, creating a single image, creating an updated sinogram from that image, and then creating an updated image. If performed iteratively, this process may then use this "second" image, but even then it is only using the second image, and is not aligning images, or otherwise using two images together.

Independent claims 1, 2, 14, 19, 104, 126, 148 and 170 are different from Arata in that there are two separate images during each iteration, one being the current working image and the other being the *a priori* image. As such, the Arata reference never performs registration between two images. Independent claims 2, 14, 19, 126, 148 and 170 are amended with a similar combination of elements of allowed independent claims 1 and 104. Specifically, these claims are amended by adding the element of extracting data from an aligned or reprojected sinogram data set that is missing from or not available in a sinogram data set having missing or incomplete data.

With regard to claims 2, 14, 19, 126, 148 and 170, the Arata reference does not disclose compensating for missing or incomplete data or the degradation that results. The method

disclosed in Arata does not correct or compensate for missing data or limited data, and limited data images would suffer from artifacts whether or not Arata's method was applied. The Arata method is not used to compensate for data that is not available, the Arata method is used to compensate for patient motion in cases where all of the data is available, but not necessarily consistent with itself. The Arata reference does not discuss, nor claim, nor enable reconstruction of incomplete data.

Further, Arata does not teach or suggest extracting data from a second independent source (the realigned, reprojected second-input image), for use in the original data set. Arata does not disclose a second-input image, and consequently does not realign it, reproject it, or extract data from it.

The augmentation process of the present invention takes data from an original sinogram, and replaces portions or complete missing portions of the original sinogram with data from a second image that has been aligned, reprojected, and had relevant sections extracted from it. The Arata reference does not disclose a second input data set, so there is no process of "augmenting" an original sinogram with a separate, independent sinogram. Instead, the Arata "adjustment" is to shift data from the original sinogram, the only original sinogram, to compensate for patient motion. Not only is the adjusted sinogram comprised entirely of data that is in the original sinogram, but the information used to detect the shift derives solely from processing done on only that original sinogram. So the Arata reference does not combine original data with data from a separate source, or even use information from a separate source as a guide for how to do the data manipulation.

Since the present invention includes two images as inputs, a third image is reconstructed from the augmented sinogram. In contrast, the Arata reference begins with a single data set, creates a single image, but does not "augment" the sinogram with independently processed data. The data is reconstructed into a second image, not a third image.

Claims 3, 5, 9, 41, 42, 60 and 61 are dependent claims dependent upon independent claim 2, and thus should be allowable for the above reasons as well as for the additional elements they contain.

Claims 18, 62, 63, 81 and 82 are dependent claim dependent upon independent claim 14, and thus should be allowable for the above reasons as well as for the additional elements they contain.

Claims 83, 84, 102 and103 are dependent claims dependent upon independent claim 19, and thus should be allowable for the above reasons as well as for the additional elements they contain.

Claims 127, 128, 146 and 147 are dependent claims dependent upon independent claim 126, and thus should be allowable for the above reasons as well as for the additional elements they contain.

Claims 149, 150, 168 and 169 are dependent claims dependent upon independent claim 148, and thus should be allowable for the above reasons as well as for the additional elements they contain.

Claims 171, 172, 190 and 191 are dependent claims dependent upon independent claim 170, and thus should be allowable for the above reasons as well as for the additional elements they contain.

Claims 4, 6, 17, 43, 45-55, 64, 66-76, 85, 87-97, 129, 131-141, 151, 153-163, 173 and 175-185 are rejected under 35 U.S.C. § 103(a) as being unpatentable over Arata in view of U.S. Patent No. 6,266,453 to Hibbard et al. Applicant respectfully traverses this rejection.

Claims 4, 6, 43 and 45-55 are dependent claims dependent upon independent claim 2, and thus should be allowable for the above reasons as well as for the additional elements they contain.

Claims 17, 64 and 66-76 are dependent claims dependent upon independent claim 14, and thus should be allowable for the above reasons as well as for the additional elements they contain.

Claims 85 and 87-97 are dependent claims dependent upon independent claim 19, and thus should be allowable for the above reasons as well as for the additional elements they contain.

Claims 129 and 131-141 are dependent claims dependent upon independent claim 126, and thus should be allowable for the above reasons as well as for the additional elements they contain.

Claims 151 and 153-163 are dependent claims dependent upon independent claim 148, and thus should be allowable for the above reasons as well as for the additional elements they contain.

Claims 173 and 175-185 are dependent claims dependent upon independent claim 170, and thus should be allowable for the above reasons as well as for the additional elements they contain.

Claims 7 and 8 are rejected under 35 U.S.C. § 103(a) as being unpatentable over Arata in view of U.S. Patent No. 6,282,257 to Basu et al. Applicant respectfully traverses this rejection.

Claims 7 and 8 are dependent claims dependent upon independent claim 2, and thus should be allowable for the above reasons as well as for the additional elements they contain.

Claims 56-59, 77-80, 98-101, 142-145, 164-167 and 186-189 are rejected under 35 U.S.C. § 103(a) as being unpatentable over Arata in view of Kudo et al. Applicant respectfully traverses this rejection.

Claims 56-59 are dependent claims dependent upon independent claim 2, and thus should be allowable for the above reasons as well as for the additional elements they contain.

Claims 77-80 are dependent claims dependent upon independent claim 14, and thus should be allowable for the above reasons as well as for the additional elements they contain.

Claims 98-101 are dependent claims dependent upon independent claim 19, and thus should be allowable for the above reasons as well as for the additional elements they contain.

Claims 142-145 are dependent claims dependent upon independent claim 126, and thus should be allowable for the above reasons as well as for the additional elements they contain.

Claims 164-167 are dependent claims dependent upon independent claim 148, and thus should be allowable for the above reasons as well as for the additional elements they contain.

Claims 186-189 are dependent claims dependent upon independent claim 170, and thus should be allowable for the above reasons as well as for the additional elements they contain.

Claims 44, 65, 86, 130, 152 and 174 are objected to as being dependent upon a rejected base claim, but would be allowable if rewritten in independent form including all of the limitations of the base claim and any intervening claims. Claims 44, 65, 86, 130, 152 and 174 are dependent claims dependent upon amended independent claims 2, 14, 19, 126, 148 and 170, and thus should be allowable for the above reasons as well as for the additional elements they contain.

In view of the amendments and remarks presented above, the Applicant believes that the application is now in condition for allowance, and respectfully requests reconsideration of the application, withdrawal of the rejections and allowance of the claims. No new matter has been added to the application. The Applicant respectfully requests that the Examiner telephone the undersigned in the event a telephone conference would be helpful in advancing prosecution of the application.

Respectfully submitted,

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